InLCA: Life Cycle Inventory Development

German Network on Life Cycle Inventory Data

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Abstract

DOI: http://dx.doi.org/10.1065/lca2004.09.180.4

Reliability of Life Cycle Assessment (LCA) results depends on the availability and quality of Life Cycle Inventory (LCI) data. In order to provide high-quality LCI data for background systems in LCA and to make it applicable to a wider range of fields, harmonization strategies for already existing datasets and databases are required. In view of the high significance of LCI data as a basis of major fields of action within a sustainability strategy, the German Helmholtz Association (HGF), under the leadership of the Forschungszentrum Karlsruhe (FZK) has taken up this issue in its research programme. In 2002, the FZK conducted a preliminary study on 'Quality Assurance and User-oriented Supply of a Life Cycle Inventory Data' funded by the Federal Ministry of Education and Research (BMBF). Within the framework of this study, a long-term concept for improving the scientific fundamentals and practical use of LCI data was developed in association with external experts. The focus is on establishing a permanent German 'Network on Life Cycle Inventory Data' which will serve as the German information and cooperation platform for all scientific and non-scientific actors in the field of life cycle analysis. This network will integrate expertise on LCA in Germany, harmonise methodology and data, and use the comprehensive expert panel as an efficient basis for further scientific development and practical use of LCA. At the same time, this network will serve as a platform for cooperation on an international level. Current developments address methodological definitions for the initial information infrastructure. As a novel element, user needs are differentiated in parallel according to the broad application fields of LCI-data from product declaration to process design. Case studies will be used to define tailored interfaces for the database, since different data quality levels will be encountered.

Keywords: Appropriateness; data integration; inventory; network

Introduction

The methodological approach of life cycle assessment (LCA) comprises an integrated view of the ecological consequences throughout the production, use and disposal stages of a product ('from cradle to grave'). This approach is increasingly applied to environmental policy, e.g., the EU-Communication on integrated product policy, as well as in industry for product and process development. LCA serves as a means of decision support in order to identify control mechanisms for a sustainable development. Moreover, LCA will be used to an increasing extent for business-to-business and consumers' information in accordance with the new EU requirements for the so-called Product Declaration Type III [1].

Data on environmentally relevant material and energy flows entering and leaving technical processes, as well as for process chains, like energy production are essential prerequisites for LCA. Thus, reliability of the LCA results depends on the quality of the life cycle inventory (LCI). In order to provide high-quality data, infrastructure for quality assurance and scientific backup of data collection and data processing are required.

In view of the significance of LCI data as a basis of a sustainability strategy, the Germany Helmholtz Association, under the leadership of the Forschungszentrum Karlsruhe (FZK) has taken up the LCI data issue as part of its materials flow-related sustainability research (research programme 6 'Sustainable Development and Technology' within the Earth and Environment research area). In 2002, the FZK conducted a preliminary study on 'Quality Assurance and User-oriented Supply of a Life Cycle Inventory Data', funded by the Federal Ministry of Education and Research (BMBF). Within the framework of this study, a national, long-term concept for improving the scientific fundamentals and practical use of LCI data was developed in association with external experts. The objective is to establish a permanent German network of Life Cycle Inventory Data. The contents of, participants in, and results of this preliminary study were presented at a workshop on November 18–19, 2002 at FZK and were documented and published in a report [2]. According to this basic concept, this network will be the common information and coordination platform for all groups involved in the supply and use of LCI data. About 30 participants from science, industry, environmental policy, and administration have already been integrated in the preliminary study. Participation of additional groups (e.g. consumer counselling) is desired.

This network will integrate expertise on LCA in Germany, harmonise methodology and data, and use the comprehensive expert panel as an efficient basis of further scientific development and practical use of LCA. At the same time, this network will serve as a platform for cooperation on an international level, like the EU COST-Action 530 or the Life Cycle Initiative by UNEP/SETAC [2].

1 Objectives

The German network is still in the start-up phase, which is focused on fund raising and contouring the organizational framework. It is understood to be a central platform for all groups involved in the supply and use of LCI data, including science, industry, policy makers and authorities, consumer counselling, environmental associations, and the interested public (**Fig. 1**). The network comprises three structural areas that have reached various stages of implementation:

- Common 'science cooperation' of the Helmholtz Association, German universities, and research institutes for research in the field of life cycle analysis;
- Web portal as a point of information exchange for all interested partners and for providing e-working functionality;
- Data pool for the supply of harmonized high-quality data for basic fields of life cycle analyses.

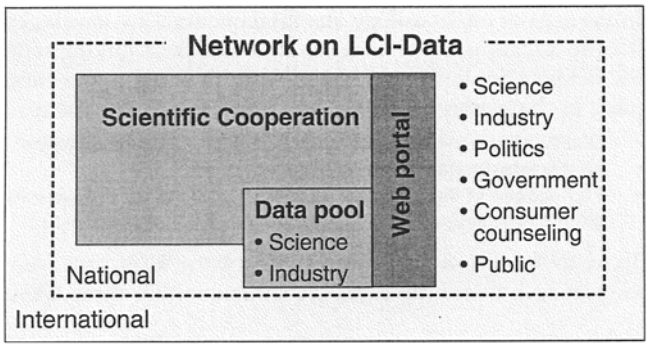

Fig. 1: German network on LCI-data

The core element of the activity is an institutionalised 'science cooperation' that is developed until 2006. This body will be a formal alliance of scientific institutions with a central organization and coordination at FZK. The scientific participants in the network possess many years of experience in the field of life cycle analyses and represent the majority of experts in German research. Groups of researchers with special expertise related to the individual issues (e.g. energy generation) and developers of LCI databases, as well as users of data and tools from very different fields of application (e.g. building sector, product development) are represented. On both sides, relevant industrial sectors are involved. As far as scientific interest groups are concerned, the Helmholtz centres cooperate with universities, universities of applied sciences, collaborative research centres, and non-university institutions pursuing distinct research interests.

This science cooperation fosters the development of a central data pool. The setup of the data pool will be accomplished in line with existing and practically relevant data formats to ensure a simple and efficient link to already existing inventories and the support of maximum dissemination in practice. Furthermore, existing exchange formats and publicly accessible data inventories will be mapped in the information infrastructure in parallel or subsequent to the networking activities.

A web portal has already been established to manage the various dialogue processes among interested parties. The complex structure of the network requires an efficient technical support of information and communication. Here, the web portal plays a central role. This web portal is tailored to the needs of the network and implemented accordingly. Apart from traditional means of information supply, modern working techniques of e-working form an integral constituent of the infrastructure. This includes discussion forums and virtual work meetings, as well as structured information and organization services.

Within the 'science cooperation', the participants agreed on three central objectives for this long-term activity:

- The scientific validation, generation and continuous update of data for life cycle analyses;
- The use of life cycle data for scientific decision support, with respect to sustainable production and consumption in varying application areas;
- Further methodological development of life cycle analyses within the research area, material flows and sustainability.

The motivation of the participants is based on operational targets, which are, in turn, beneficial for the individual member:

- Coordination of research projects and an increase in the efficiency of the scientific work and use of the research results;
- Generation of a research platform, establishment of a representation of the research area, and the ability to reach out for third party funding;
- Coordinated incorporation of German know-how in interests in international activities.

These structural, organizational and contextual aims will be reached by an overarching scientific research programme, which can be understood as a scalable framework for data acquisition and application, as well as methodological developments. The multi-stakeholder approach guarantees an application-oriented and consensus-oriented development of research issues and provides for a wide acceptance and multiplier effect of the results obtained.

2 Scientific Work Programme

As a result of the preliminary study, a work programme has been set up, revised, and made more specific in intensive discussions. The programme is designed to cover the next three years and consists of three interdependent parts (**Fig. 2**):

- Supply of LCI data
- Application of LCI data
- Methodology

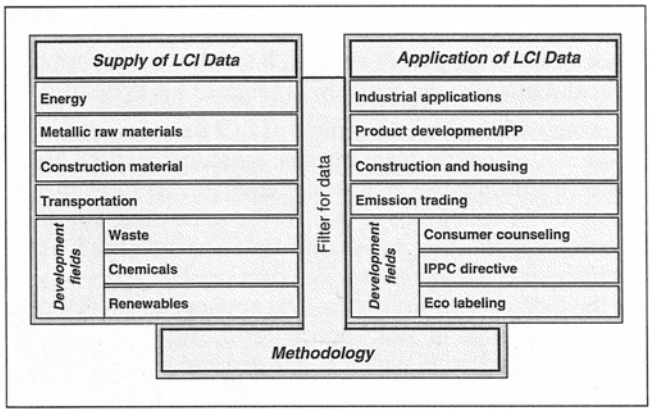

Fig. 2: Themes of the scientific work programme

Within each part, several themes are identified. The themes follow the priority setting within the preliminary study and provides a snapshot of current concerns and important issues. Each theme is the name of a corresponding working group (WG). Each working group is represented by a scientist within the overarching Methodology WG, which also has a coordinating function for the different themes and cross-cutting issues. Upcoming themes have already been identified as areas for further activities, but, so far, they are not supported by working groups.

The findings of the WGs are brought together in the area of basic methodology. It is aimed at developing the scientific basis for compatibility and, if possible, harmonizing the different approaches within and between the individual areas. Due to its significance in terms of content, this WG also has a steering function.

2.1 Supply of LCI data

Activities in this area are aimed at developing a data pool for LCI data in order to supply harmonized and reviewed basic data for background systems. The main tasks for the working groups within this part of the work programme are to establish data acquisition schemes for the major basic data, guaranteeing the validation, generation, harmonization and continuous update of datasets, and to establish the review process together with responsible institutions. Each theme is characterized by a specific combination of involved scientific, industrial and governmental bodies. In commodity-specific themes like Construction Materials or Metals, industry associations, and in many cases market competitors are sitting at the same table. The lack of consistent and comparable data is of major concern here.

Within the service orientated themes, Energy and Transportation, public data is often available in a variety of models, but harmonization and modelling choices often collide with market positions of competitors. Between the themes, overlaps occur which require careful coordination to avoid duplication.

2.2 Application of LCI data

Similar to the supply side, the structure and themes of the application part are a result of the preliminary study. A major part of the work in the individual fields of application consists of identifying the application-specific requirements to be met by the data from the user's point of view, in terms of both form and content. Within the network, application of LCI data is not meant to support LCAs only, but rather to support, promote and broaden the application range of life cycle data.

Working with major user-groups of LCI data, and members of the non-scientific field, durable structures will be established to continuously assess the requirements to be met by the data and conditions of use. At the same time, interfaces for certain application environments will be developed. These interfaces will act as filters in the data pool, in order to supply the data desired for the specific application. In this way, problem-oriented or task-specific applications of the information infrastructure will be supported and enabled. Within the scope of these working groups, criteria for the appropriateness of data are also to be developed.

2.3 Methodology

The Methodology WG has an overarching position, since all methodological choices and approaches within the separate themes must be integrated within a continuous workflow. Therefore, this working group is organized like a steering committee with representatives of the different WGs. Within this WG, overarching and general issues are discussed. By means of a guideline for data capturing and maintenance, consensual issues are codified and contentious issues are fed into a discussion process. Centralized coordination of methodological specifications will link the supply of basic data with the consideration of the users' views.

The working group aims at useful methodological specifications for supply, update, and review of LCI data. The issues: Methodological Development, Data Quality, Data Collection, Data Filter and IT implementation, which includes a data exchange format have been specified in detail.

In the area of methodology, the fundamentals are developed for the harmonization of basic data and their linking with the fields of application. Methodological know-how is compiled in the methodology guideline and serves as basis for:

- Quality assurance and consistency of existing data inventories;
- An efficient update of data inventories;
- An increase in the safe use of data inventories by various user groups (industry, administration, consumer counselling, etc.).

To focus the discussion within and between WGs, case studies are used. Currently cases are studied within three WGs.

2.4 Case studies

The initial focus of the network activity is not on a novel data acquisition campaign, but rather on the re-use and 'recycling' of existing data and the establishment of a framework for continuous data supply and quality maintenance. In order to identify key-issues, case studies are currently carried out. Their connecting element is the harmonization of existing datasets with different study origins and scopes.

Harmonization in this stage means to understand and document the differences in data sources within a common framework. Data harmonization is a prerequisite for data integration. Normalization of data, which would require recalculation and additional data collection is currently out of the scope of harmonization.

Within the Energy WG, case studies are aimed at selected energy carrier systems (coal, natural gas, etc.) for the German energy mix, which is based on a comparison of different datasets with respect to collected processes, system boundaries, geographical sources, materials properties etc. In one case study, the Construction and Housing WG deals with the variety of application cases for LCI-data from materials selection to the design of buildings. To exemplify characteristics of such case studies the Metals WG is explained in more detail.

The Metals WG is responsible for the harmonization of existing data on metal production. According to their quantitative importance, a subset of metals has been selected (Fe, Al, Cu, Zn, Mg). Activities related to the pilot project of 'Generation and Harmonization of Modules for the Life Cycle of Aluminium Production' comprise the exemplary study of existing

data inventories with the objective of generating a representative dataset. First, a general qualitative basis will be created for the future metal-overlapping methodology of data collection. As suitable metal aluminium was chosen, which might be characterized by an extraordinary data availability from different sources and the process chains can be represented relatively easy compared to the production of other metals.

The data base to be evaluated within the framework of this pilot project consists of the following three different data sources, representing typical data acquisition schemes:

- The environmental profile report for the Aluminium industry [6] is based on questionnaires covering the European Aluminium industry. An expert panel and extensive external reviewing lead to a condensed table of exchanges designed for the utilization in LCIs.
- The investigations of the Federal Agency for Geosciences and Resources (BGR) on material flow and energy requirements for the production of selected mineral commodities [7] is focused on a limited spectrum of exchanges and is also based on questionnaires and an international survey.
- The results of the Collaborative Research Centre (CRC) 525 [8] as a joint scientific programme between the institutes of the Aachen University of Technology and the Forschungszentrum Jülich are based on an extensive literature review, field work, and laboratory experiments. The study reveals a detailed view with attributional, as well as consequential modelling elements.

Even if the BGR and CRC 525 studies were not conducted as standardized LCIs, they represent typical primary data sources exemplary for a vast variety of non-LCA sources, which are to be considered in the scope of the network activity.

Good coordination of the pilot project with parallel activities is of crucial importance, particularly as the development of general requirements by the Methodology WG is concerned. This allows for a final review of the data collecting on the basis of a coordinated procedure by the Methodology WG only (**Fig. 3**).

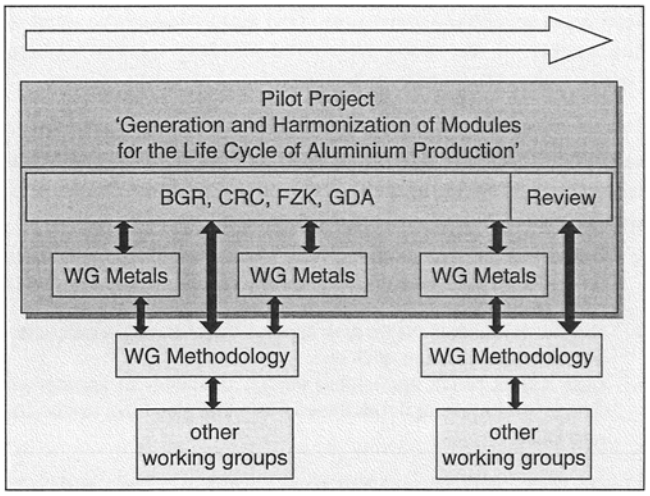

Fig. 3: Schematic workflow of the pilot project

3 Data Quality

Data quality of LCI data and its continuous improvement is a central target of the network activity. Important documents which have been compiled in the LC community, such as the conceptual framework for a Quality Assessment [3] or the Code of Life Cycle Inventory Practice from the SETAC Workgroup on Data Availability and Quality [4] are fully taken into account. Also of crucial importance are already operating LCI database projects, like the Swiss ecoinvent[1] database or the Swedish National LCA database SPINE@CPM[2].

Data quality as general term has a broad meaning for LCAs in general, considering the complex interdependencies between goal and scope, inventory modelling, impact assessment, and interpretation. A generic quality assessment for LCIs is undoubtedly dependent on a specification of framework conditions.

In the Code of Life Cycle Inventory Practice, quality is addressed from the list of recommended exchanges[3] via inventory modelling through an evaluation framework for uncertainty in LCI [4]. Nevertheless, LCI data quality is relative, not only according to other phases of an LCA, but also according to different value choices. During a workshop on LCI quality in 1992, the participants assigned preferences for selected data quality indicators (DQI) considering study type, objective and level of detail [3] (**Table 1**). This rather subjective value choice illustrates, that 'high quality' may not be a single attribute for either a unit process or a dataset. Rather, it should be considered as a level of appropriateness of data selec-

[1] www.ecoinvent.ch
[2] www.imi.chalmers.se/Projects/Finalised/SPINEatCPM/
[3] Exchanges are used according to [3] replacing the term 'intervention' in the ISO-framework.

Table 1: Data quality indicators [3]

Qualitative DQIs	Type of Study			Study objective			Level of Detail	
	Single Product / Plant	Product Group	Regional / National / International	Ecolabeling	Product related decision (internal)	Pollution Prevention (Public Policy)	Screening	Detailed
Representativeness	Y	N/Y	N	N	Y	N	N	Y
Transparency	Y	N/Y	N	N	N/Y	N	N	N
Peer Review	N	Y	N	N	N	N	N	Y
Consistency	N/Y	N/Y	N	N	N/Y	N	N	N

N/Y: Some variability exists among practitioners/studies. These ratings reflect the circumstances at the time of the workshop (October 1992)

tion for a specified application. This supports management of the variety of use cases and corresponding quality requirements rather than striving for single and absolute scores.

For the network and the central WGs, it is a core element to establish a flexible matrix of datasets, unit processes, levels of appropriateness, and the elaboration and specification of quality criteria and indicators through:

- Guidelines for data capturing (WG Methodology): documentation and general specification of all quality criteria, especially a third party review;
- Review of datasets (WGs data supply): internal review on quality, but also quantification of DQIs;
- User needs (WGs application fields): definition of appropriate dataset properties and rule-based filters that also have to incorporate DQIs.

Due to the organizational structure, common criteria and commitments which are essential to the scope of the project are established jointly by the WG Methodology. Mandatory elements for a unit process' data documentation are currently:

- Kind of data (measured, literature, etc.);
- Age and timeliness of data;
- Accuracy and precision of data.

Elements for discussion are:

- Additional quantitative DQIs;
- Treatment of data gaps and zeros;
- Treatment of different estimation techniques (conservative, optimistic, etc.);
- Lists of recommended exchanges.

Another important area for discussion is the documentation of system data (consisting of a variety of unit processes) and appropriate DQIs, as well as a comprehensive third party review scheme.

The thematic WGs on the data supply side provide an opportunity to extend common elements of the quality documentation and assessment with specific measures and criteria. It is considered important that sectors, like metals or energy, are able to define additional criteria that allow a specific assessment of each background system. As an example, the degree of accordance between the year of the study and the year of collection of the obtained data suggested by Weidema [4] is an important DQI. But, the interpretation of this degree might be different among different sectors according to their specific dynamics and different data update periods. The involvement of industry representatives in these WGs will facilitate the input of actual data about sectors but also primary data sources.

Since these technical WGs also provide a feedback on which criteria and corresponding DQIs are meaningful and accessible for data acquisition and reporting, the WGs responsible for the application of LCI data play an essential role in bridging the gap between the technical LCI part and real-life application fields. The broad scope covered by these WGs suggests that a single and uniform DQI-scheme will not suffice. The approach here is, to design application-specific filters, which contain rules for the treatment of different data quality levels, depending on the desired decision context.

4 Conclusion

The German Network on Life Cycle Inventory data is a co-operative approach for the continuous supply of LCI data within a broad scope of potential applications. Key characteristics of the networking activity are:

- The integration of stakeholders from scientific institutions, consultants, commodity industries, and governmental institutions;
- The central co-ordination of sector- and application-specific working groups;
- The joint development of research strategies and collaborative programmes.

Visible activities are:

- Active participation within ongoing international initiatives (EU COST 530; UNEP/SETAC Life Cycle Initiative);
- The web-portal, which is continuously adapted to the need of its users since its start up in July, 2003 (www.lci-network.de);
- Organization of national and international workshops (http://www.lci-network.de/lci-quality);
- Case studies.

Future key prospects comprise:

- The development of a sustainable business model;
- The establishment of an information infrastructure matching the needs for a continuous supply of assessed LCI data for background systems.

Within this scope, it is essential to determine differences and similarities with 'mature' projects like the Swiss ecoinvent database or the Swedish LCA database SPINE@CPM.

Acknowledgements. The presented paper is based on a multidisciplinary, multi-stakeholder dialogue and would not have been possible without the aid of the network as platform for mutual discussions and exchange. The authors wish to thank all participants of the German Network on LCI-data who contributed to working groups and constructive discussions.

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Received: June 16th, 2004
Accepted: September 27th, 2004
OnlineFirst: September 28th, 2004